Integral Automatic Control System for Premixed Concrete Production Companies (Dosat_H04)

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ABSTRACT: DOSAT H04 is an integral automatic control system for the production and sales management of premixed concrete in cyclical operation gravimetric plants. This system is a tool that guarantees to obtain an stable quality in the production of premixed concrete, and also to control the material resources and invoicing issues of the company. The system is implemented on a PC with Windows98, Windows Me, Windows NT 4.0, Windows 2000 or Windows XP using a TCP/IP protocol for data transmission.

DOSAT H04 is modularly designed so that it can be installed in companies with one plant or more than one plant, covering from the placing of the order, the automatic control of concrete production, inventory control of raw materials, transportation, up to the invoicing to the client.

In the case of companies with more than one plant the system includes:

- Weighing system: formed by string gates, manual control desk, and measuring terminal.

- PC and control software: the computing system presents an intuitive and easy to handle graphic interface that allows to introduce an unlimited amount of recipes, and strong and efficient control program with three types of controllers including a PID, compensation of humidity, etc.

- Global Orders Module: this software attends the creation of contracts of Global Orders that are to be sent to the production plants or to the dispatcher via e-mail, internet, intranet, floppies, etc.

- Daily Orders Module: this software was designed for companies with a dispatcher who divides Global Orders into Daily Orders and distributes them among the different Plants according to their geographical location, production capacity, etc.

- Reporting and Invoicing Module: this software receives information from the different plants and issue more than 90 reports itemized as Production Process Reports, Raw Material Reports, General Transportation Reports, and Client Invoicing Reports.

For companies with only one plant:

In this case the software of control undertakes the functions of the other programs, thus providing all the necessary reports, including the client invoicing information.

Since 1998, with this system 18 plants have been installed in Cuba obtaining the following advantages:

- Quality stabilization of concrete production

- A more rational use of labor

- Reduction in human errors

- Increase in the production rate of the plant

- Increase of operation hours between maintenance stops

- A more strict control of the resources

- Reliable and up-to-date invoicing of the concrete production

KEYWORDS: DOSAT_H04.

1. INTRODUCTION

Dosat_H04 was designed to satisfy the need in Cuban concrete production companies of a reliable tool that allows the automation of the production process, an strict control of material resources and also to carry out the billing to the clients. Consequently the fundamental objectives of the system described in this work are:

- To keep a digital register of the global orders placed by the clients.

- To assure that during concrete production the mixture is prepared using the exact amount of each component (arids, cement, water, and additives) as it is specified in the recipe.

- To guarantee a stable quality of the concrete produced in the plant during its entire useful life.

- To minimize human errors that may occur during the manufacturing process.

- To have reliable information at any moment about material resources as well as of the production of the company.

- To carry out the invoicing to the clients.

2. COMPONENTS OF THE SYSTEM

This system is formed by 4 interrelated subsystems covering from the placing of the concrete order by the client, the computer control of the concrete production process, to the final invoicing to the client. The subsystems are: Global Orders Module, Daily Orders Module, Control of Process Module and Reporting and Invoicing Module.

2.1 GLOBAL ORDERS MODULE

This software is usually installed in the sales department of the company and it is devoted to attend the creation of global concrete contract orders, and to keep databases of clients, building works, etc. After the general orders are created, the program sends the information to the computer where the Daily Orders Module is installed if the company has more than one plant, or to the Process Control Module if there is only one plant. This transmission is carried out through the TCP/IP protocol and that's why the computers must be interconnected in a net like a LAN, intranet, Internet, etc.

2.2 DAILY ORDERS MODULE

As it was previously mentioned, this program is used only in companies with more than one plant and it is in charge of receiving the general orders, divide them in suborders that will be transmitted daily (by TCP/IP) to the different plants, according to their geographical location and capacity of production. It possesses the same databases as the Global Orders Module and also a database of the different plants.

2.3 CONTROL OF PROCESS MODULE

This subsystem is in turn divided in 3 fundamental parts:

- Weighing system

- Manual control desk

- Controlling computer

2.3.1 WEIGHING SYSTEM

It is formed by string gates for measuring the weights in each scale of the plant (See Figure 1) and by the measuring terminal which determines the weight properly said, by measuring the resistance variations of the cells. It has a digital indicator to show the weight in the manual control desk and also communicates with the controlling computer, via a transmission series cable RS232, to send the amount of the weight in each instant (See figure 2).
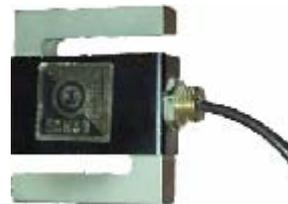
Figure 1. String gates.
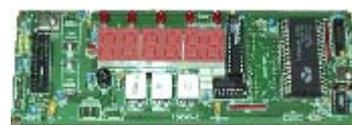
Figure 2. Measuring Terminal.

2.3.2 MANUAL CONTROL DESK

It is a steel desk that contains the previously mentioned measuring terminals and other electric components to operate the plant. In its surface are installed the digital indicators of weight in each scale, and the push-button that handle each component of the plant. As its name indicates, it allows the operator to run the plant manually, without the need of using the controlling computer . Its use is anticipated only for emergencies, when the controlling computer is out of order (See Fig. 3).

Figure 3. Manual Control Desk.

2.3.3 CONTROLLING COMPUTER

It is a regular personal computer, to which some electronic interfaces are added for measuring different variables of the production process and to operate the elements of the plant. The Control Program is installed in this computer (See Fig. 4).

Technical characteristics of the Control Program: This software is implemented on a PC to operate under Windows98, Windows Me, WINDOWS NT 4.0, Windows 2000 or Windows XP and the data transmission is carried out by means of TCP/IP protocol. It is designed to be configured according to the structure and the requirements of the plant where it will finally function.
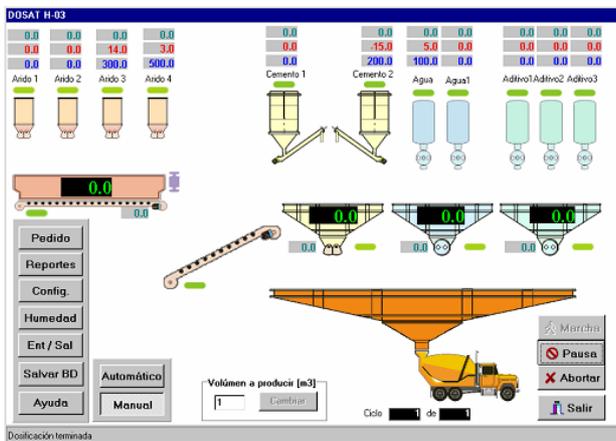

Figure 4. Control Program Frontal Panel Interface

Main configurable parameters:

- Name of the plant.

- Volume of each cycle in m^3 (capacity of the plant).

- Amount of elements of the plant (arids hopper, cement silos, etc.).

- Whether or not the plant has an independent scale for cement.

- Whether or not the discharge of the materials is carried out automatically after the weighing process or by a command of the operator.

- Whether or not the plant has a mixer installed.

- Whether or not compensation among cycles is wanted.

- Whether or not additives are used.

- In case of using additives, whether the scale is independent or it shares the one for the water.

- Whether or not the plant has vibrators.

- Type of arids transportation.

Given its open architecture, the equipment can accept humidity sensors in arids and of temperature in cements.

It also has a set of interrelated databases that allows to process different types of economic and administrative information of the company.

Databases:
- Clients

- Building works

- Orders

- Suppliers

- Recipes

- Materials

- Trucks

- Truck drivers

- Materials movements: In or out from the plant

- Manual loading: Information of manual dosages in the plant

- Invoicing: Information about the dispatching of concrete to the clients

It generates different reports that the operator can select. These reports are classified in three groups:

- Production reports: They offer all the information about the process of production like summaries of dosages, production general reports, manual operations, eventualities, etc.

- Raw materials reports: They offer information about the movement of materials and their indicators

- Transportation reports: They offer different information about the transportation of concrete; that is to say, general transportation activity, truck activities, transported volume, traveled distances, etc.

Characteristics of Operation:

- Independent control of up to 6 scales. The operational cycle of each scale is independent from of the others.

- Automatic linkage of the cycles. The working cycles are automatically concatenated according to the concrete volumes to be processed.

- Capacity to store a limitless amount of recipes.

- Control of users by passwords for changing the configuration of the system. In this way it is assured that only the authorized personnel can change the configuration parameters.

- Automatic calculation of the amount of cycles. The amount of cycles are calculated according to the concrete demand and the capacity of the plant. This information is indicated in the frontal panel interface together with the number of the cycles that is currently under process.

- Auto tare. The weight of each scale at the beginning of a cycle is considered when determining the weight of the material to be dosed.

- Double use of one scale. Possibility of dosing arids and cements in the same scale.

- Dynamic adjustment of the vein. Each time a weighing cycle of a material ends, the value of the vein is adjusted according to the amount of material below or over the dosed amount.

- Correction of the amount of water according to the humidity of the arids. Starting from a particular percent of superficial humidity introduced through the keyboard or by the sensor for each arid, the correction of water and arids is performed up to a second degree to obtain an adequate balance in the final mixture.

- Materials double flow dosing. In order to obtain the most precision in the dosage of cements, the process can be controlled in two stages: a quick initial one, where most of the amount is dosed; and a final slow one, where the last kilograms are dosed.

- Additives dosing. Additives can be dosed in a volumetric or gravimetric way.

- Constant checkup of the scales. When an scale parameter like capacity or tare is exceeded, an error message is sent to the operator.

- Error correction in Materials dosing. The amounts below or over their corresponding values that were dosed in a cycle are corrected in the following cycle.

- Printed outputs of the results at the end of the dosing process. Actual and expected values are printed as well as any other report requested by the client.

- Inventory in kilograms of each material.

- Possibility of printing the recipes, and the configuration parameters.

- Tolerance control. The production process is stopped whenever a material scheduled tolerance is exceeded.

- Possibility that the operator pauses the process. The process can be paused at any moment that the operator determines, in case of difficulties during the process of production. After solving them, the operator can resume the process.

- Unload of the scales by stages. It is possible to define up to three unload stages.

- There are three types of procedures for the transportation of the arids:

✓ Direct. The arids are directly discharged by gravity into the concrete mixer or the concrete mixer truck.

✓ Conveyor belt. The arids are discharged on a conveyor belt for carrying them to their final destination. In this case the program considers the time the conveyor belt takes in transporting the materials; this parameter is also configurable.

✓ Skip. The arids are transported in a receptacle well-known as Skip. In this case the program keeps track of the ascending and descending movements of the Skip.

- Automatic control of the blending and emptying procedure in stationary mixer. The blending and discharging time can be programmed in such a way that the operator doesn't have to participate in this part of the process.

- Opening and closing control of the gates. The condition of open or closed of each gate is supervised by checking the signals coming from run-end indicators that could be installed in the gates. If the corresponding signs are not generated after having elapsed the scheduled time for opening or closing of the gates, a signal is emitted indicating such condition.

- Intermittent discharge (emptying) of scales. The opening and closing times for the discharge of the gates are programmed by the user. This prevents truck overflows of materials.

- Alternatives for loading the mixer. There are two possibilities to be selected by the user:

  ✓ Independent discharge cycle. When the weight is reached, the contain is discharged into the mixer and the next weighing cycle begins, without the need to wait for the weighing and discharging of the other scales.

  ✓ Discharge cycle commanded by the operator. Once the weight is reached, the operator is informed that the materials are already weighed and his confirmation is awaited for discharging them into the mixer.

- Three configurable methods to carry out the automatic control of the dosing:

  ✓ Using an On-Off Control. It allows to define the period of control.

  ✓ By means of a PID Control. The parameters previously defined by the controller can be adjusted during the process.

  ✓ Using an On-Off Control with intermittent leaking . This procedure begins with an On-Off Control and ends with an intermittent leaking system.

- Configurable discharge control. For the discharge it's necessary to consider the following parameters: maximum tare, time of maximum tare, and time of discharge; all of them can be configured by the operator.

- Help: The operator has a very easy Help with the explanation of all configurable parameters and specific instructions about the operation of the system.

Operation:

The system presents a very intuitive graphic interface, of easy handling and understanding, and because of it there is no need to have previous computer knowledge to operate the system. Thus, after the plant is configured and defined the humidity of the arids (which can be introduced by keyboard), the operation is very simple: the operator selects the desired recipe, defines the concrete volume to manufacture and pushes a button; then he only has to wait for the plant to finish the production of the amount of concrete that was ordered. After finishing the whole process, he can know the particulars details by selecting the appropriate production reports.

2.4 REPORTING AND INVOICING MODULE

This module is a software that collect the information from the different plants and allows to issue the billing of the production to the clients and to print the different reports previously detailed in the section devoted to explain the control program. Therefore, this module centralizes the information of the general activities in all plants.

3. CONCLUSIONS

At present in Cuba there are 71 premixed and prefabricated concrete plants in operation; 24 are automated and 19 of them are using this system which, besides the objectives outlined in the introduction of this document, the following advantages have been attained:

- A more rational use of labor in the plant, as the automated system assumed functions that previously required more personnel.

- An increase in the speed of production of the plant, in some cases up to 50%, because the system can simultaneously weigh materials in all the installed scales, thus reducing the processing time in each cycle of the plant.

- Possibility of having a better control on the consumption of raw materials, taking advantage of the reports offered by the system.

- Reduction of the invoicing time.

- Reduction of costs.

- Higher general efficiency in the operation of the company.